CANADIAN CONTRIBUTIONS TO THE GROUP OF SEISMIC EXPERTS (GSE) OF THE CONFERENCE ON DISARMAMENT (CD): MARCH '85

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CANADIAN PARTICIPATION IN THE GSE TECHNICAL TEST (OCTOBER 15 - DECEMBER 15, 1984)

1.0 DATA ACQUISITION, ANALYSIS AND TRANSMISSION OVER THE WMO/GTS

1.1 DATA ACQUISITION

1.1.1 STATION GAC (Glen Almond, Quebec) -

GAC is one of the 19 stations of the Eastern Canada Telemetered Network (ECTN). Three component data in both short- and long-period bands is acquired using a model KS-36000 tri-axial seismometer installed at 100-meter depth in a cased borehole. At the site the three short-period signals are each digitised at 30 samples per second and the three long-period signals at one sample per second. The data are transmitted to Ottawa by radio telemetry at a rate of 1800 baud.

At the data laboratory in Ottawa the real-time data streams from all member stations of the ECTN are monitored by an event detection algorithm and if any one (or more) stations trigger this detector, data from all sites is saved in a buffer area on disc; if no sites trigger the continuous data stream is discarded. Since the ECTN is primarily intended to monitor local seismicity, the detector characteristics are tailored to trigger on signals which are, in duration, envelope and frequency content, characteristic of events recorded at short (less than 500km.) distances. For the duration of the GSETT, the bandpass of the detector prefilter for station GAC only was changed from (2-5 Hz.) to (0.5-2 Hz.) in order to enhance detection of teleseisms. The detector was applied to the short-period vertical component only, but all three components are saved during detections. Analogue helicorder records are made from both short- and long-period vertical channels of GAC.

On a daily basis, an analyst studies both the computer-generated station trigger lists and the analogue helicorder records in order to identify events of interest. The latter are, after analysis, saved on tape, and the events deemed to be of no interest are deleted. As stated above, the primary function of the ECTN is to monitor regional seismicity, so in general teleseismic signals are not saved. During the GSETT, a special effort was made to identify all signals recorded at GAC, including teleseisms. The three-component long-period data is kept in its entirety.

Station GAC is one of the noisier sites of the ECTN in the short-period band, and is subject to daytime bursts of high (3+ Hz.) frequency noise which is clearly cultural in origin but has not been identified. The radio telemetry used to relay the data to Ottawa is subject to sporadic interference 'spikes', and in very cold conditions ice on the antenna causes such severe interference that the data is unusable for periods of many hours at a time. Despite these various problems, GAC was selected for the GSETT because it is the only 3-component station of the ECTN and the long-period noise levels are very low by virtue of the borehole installation.

1.1.2 STATION MBC (Mould Bay, Northwest Territories) -

MBC is one of 16 'Standard' Canadian Network stations, equipped with three orthogonal short-period seismographs (Willmore type) and three orthogonal long-period sesimographs (Columbia type), each producing a photographic record. The remoteness and inaccessibility (supply flights once a month or so) of Mould Bay made it impossible to transfer the analogue records to Ottawa in a timely manner, so the MBC station operator was specially trained to measure the minimum set of parameters required for the GSETT. The records were read shortly after being developed and a message in WMO/GTS format composed. This was transferred to Resolute, some 500 km. to the east, by radio telex. From Resolute the message was relayed by satellite link to a ground station near Montreal and thence to Ottawa. It proved impossible for a variety of reasons to enter the message directly into the computer used for the GSETT in Ottawa, so it was retyped from a paper copy.

Mould Bay is normally one of the quietest sites in Canada, and this seems to have continued to be the case during the GSETT. At the beginning of the Test a very large number of high frequency signals from ice cracking during freeze-up of the adjacent bay and the surrounding ocean were recorded; these signals were easy to identify and were not reported.

1.1.3 ARRAY STATION YKA (Yellowknife, Northwest Territories) -

The medium-aperture, short-period vertical array at Yellowknife has been in operation since 1962, and consists of 18 Willmore Mark II seismometers set in the form of an asymmetrical cross at 2.5 km. spacing. Data from each site are transferred to the Array Control Centre by analogue radio telemetry. At the Control Centre an on-line digital processing system remotely monitors and calibrates the various sensors, digitises the signals at 20 samples per second, forms 121 beams in real-time, and processes the data with a detection algorithm. The detection scheme used is set to trigger on teleseismic signals; detected events are saved on tape.

The quality of telephone lines into Yellowknife is too poor to permit direct transfer of the fairly large volumes of digital data generated by the array, and it proved necessary to physically transfer the tape of detected event waveforms from Yellowknife to Ottawa. A variety of means for this were tested, and the fastest (1-4 days) and most reliable turned out to be Priority Mail, an express mail service provided by Canada Post.

As at MBC, the winter is the time of lowest noise in the short-period band at YKA. Ice cracks occuring during freeze-up of Great Slave Lake were seen on the records during much of November; they were not reported but caused many 'false' triggers. The detector trigger threshhold was reduced from its normal setting of 3.5 to 2.75 or 3.0 during the Test; adjustments were made to keep the detection rate fairly steady at between 20 and 50 events per day.

1.2 STATION OUTAGES

At all three stations used there were data outages of varying severity. Table 1 lists the out times at each station and the reasons, where identifiable. The percentage 'up' times at GAC, MBC and YKA were 99.2, 99.6 and 90.4 respectively.

1.2.1 GAC -

Constant spikes, caused by antenna icing, made the data completely unusable for some 12 hours in mid-November. Digital recording system failures resulted in the loss of long-period digital data on three separate occasions; LP vertical readings could be made from the analogue helicorder records, but the horizontal component channels were irretrievably lost.

1.2.2 MBC -

The few short down periods at Mould Bay were due to routine maintenance and equipment replacement.

1.2.3 YKA -

The major portion of the 'outages' reported for YKA were due to difficulties experienced in reading the digital tapes produced at the Array Control Centre. Bad records in some tapes proved impossible to decipher and in some instances it was not feasible to read the remainder of the tape due to a combination of hardware and software problems, though probably the rest of the tape was

TABLE 1

STATION OUTAGES AND THEIR CAUSES

GAC - Glen Almond

((OUT GAC NOV12 130500 TO NOV13 011500))	Spikes due antenna icing
((OUT GAC LPN LPE DEC07 082800 TO DEC07 080000))	Loss of digital recording
((OUT GAC LPN LPE DEC07 224500 TO DEC08 124300))	Loss of digital recording
((OUT GAC LP DEC12 125100 TO 144500))	Loss of LP data channels

MBC - Mould Bay

((OUT MBC OCT20 175200 TO 183300))	Equipment changes and checks
((OUT MBC OCT29 180400 TO OCT29 181900))	"
((OUT MBC NOV03 180900 TO NOV03 182900))	"
((OUT MBC LPN LPE NOV03 183300 TO 184700))	"
((OUT MBC NOV17 180490 TO NOV17 211900))	"
((OUT MBC NOV20 180900 TO NOV20 182600))	"
((OUT MBC DEC01 180700 TO DEC01 183100))	"

YKA - Yellownife

((OUT YKA SPZ OCT27 153000 TO OCT28 153000))	Data tape unreadable
((OUT YKA SPZ NOV09 080800 TO NOV09 150900))	Recording system failure
((OUT YKA SPZ NOV09 150800 TO NOV09 170500))	Data tape unreadable
OUT YKA LPZ NOV09 193000 TO NOV09 214220))	Calibrations
((OUT YKA SPZ NOV15 160800 TO 203500))	Recording system failure
((OUT YKA LPZ NOV16 102200 TO 160900))	Calibrations
((OUT YKA SPZ NOV16 201700 TO NOV17 155000))	Tape unreadable
((OUT YKA LP NOV19 173900 TO NOV19 192000))	Calibrations
((OUT YKA SPZ NOV20 165300 TO NOV20 165900))	YKA computer failure
((OUT YKA SPZ NOV20 210100 TO NOV20 212900))	"
((OUT YKA SPZ NOV20 193500 TO NOV20 194000))	"
((OUT YKA SPZ NOV21 085300 TO NOV21 085800))	"
((OUT YKA SPZ NOV21 202800 TO 203100))	"
((OUT YKA SPZ NOV21 210300 TO 212000))	"
((OUT YKA SPZ NOV22 214200 TO NOV24 160200))	Data tape unreadable
((OUT YKA LP NOV29 170400 TO NOV29 194800))	Calibrations
((OUT YKA SPZ DEC01 171800 TO 185600))	Data tape unreadable
((OUT YKA SPZ DEC02 062400 TO DEC03 155600))	"
((OUT YKA SPZ DEC05 153200 TO 212500))	Recording system failure
((OUT YKA LPZ DEC07 160800 TO 174500))	Calibration sequence

'good'. With some effort it should be possible to recover much of the 'lost' data, but time to do this was not available during the Test. The array itself was functioning properly more than 99% of the time.

The recording system computer at the Yellownife control center was out for short periods of time. Towards the end of the Test, power supplies at some of the outstations failed due to low temperatures (-45 C). The analogue long-period vertical seismometer was calibrated at roughly 3-weekly intervals and outages of two hours or so occured at these times.

1.3 DATA PROCESSING

1.3.1 GAC -

This station was selected as the one for which the full set of parameters was reported. The digital data was analysed using the in-house waveform analysis package described separately in GSE/CAN/10. Particular attention was paid to using the three component capability of the station.

Frequent ambiguities arose in the measurement of the long-period parameters M1L, M2L etc. - in many cases the cycle closest to the desired period was substantially smaller in amplitude than a nearby cycle whose period was not as close to that required but differing from it by less than 2 seconds period. This ambiguity should be resolved. N1LZ could not be measured at GAC because the instrument 'magnification' is very small at periods below 10 seconds.

No real problems arose in the determination of the short-period parameters M1X, M2X etc. The short-period background noise (NSZ) proved somewhat troublesome to measure because of rapid fluctuations in dominant period, and it was seldom possible to predict which portion of the noise would give the largest GROUND amplitude (the largest TRACE amplitude is of course unambiguous) when corrected for instrument response. In retrospect it would have been more satisfactory to have measured the noise amplitude from a band-pass filtered version of the waveform. The only measurements which it proved possible to make from the short-period horizontal components were those of maximum S or Lg amplitudes for local events. The most prominent phase recorded from many very local events was the short-period (1-2 seconds) fundamental mode Rayleigh wave, commonly known as Rg; this was reported (coded RG) at the start of the test, but this practice was discontinued after complaints from the Washington IDC (see COORD message SEAU10 N42009) to which this practice was apparently offensive.

TABLE 2 - SUMMARY OF PARAMETERS MEASURED AT STATION GAC

Total of Short Period Signals Analysed	168
Measurements of M1X	162
Measurements of M2X	116
Measurements of M3X	96
Measurements of M4X	68

Total of Long Period Signals Analysed	301
Measurements of MLRZ	301
Measurements of M1L	10
Measurements of M2L	292
Measurements of M3L	289
Measurements of M4L	222
Love waves measured	69

Distribution of Reported Dominant Period of MLRZ

Reported Period (sec.)	# of reports	Reported Period (sec.)	# of reports
12	1	30	17
14	4	32	7
16	16	34	10
18	52	36	1
20	52	38	0
22	60	40	4
24	32	42	1
26	28	44	0
28	13	46	2
		48	1

It is perhaps of interest to note the frequency with which the various level 1 parameters could be measured, and the measurements made at GAC are summarised in Table 2. Although the number of M4X measurements is less than that of M3X, the number of M3X measurements less than that of M2X, and so on, as might be expected, the analysts were somewhat suprised at the relative frequency with which the later (M3X, M4X) parameters were measurable. It is possible that this may to some extent be characteristic of a station with a relatively high background noise level, inasmuch as most of the teleseismic signals reported at GAC were from largish events which typically generate signals of longer duration than small events.

The long-period parameters M2L, M3L and M4L could all be measured for over 70% of the events for which LR (and MLRZ) was obtained. M1L could only be determined for a few large, relatively close events, because of the rapid falloff of the GAC instrument response at periods of less than 15 seconds. Love wave measurements (LQ, MLQN and MLQE) could be made for less than one quarter of all the events for which Rayleigh waves were observed. The last entry in Table 2 shows the distribution of dominant periods reported for MLRZ. Most dominant periods are in the range 16-26 seconds, but dominant periods as large as 48 seconds were reported, presumably for very large and distant earthquakes.

1.4 MBC

MBC data was analysed by the station operator (minimum set of parameters only) and no particular problems were reported. The noise values for N2LZ could not be measured because of the particular instrument response; the background noise was overwhelmingly dominated by the 4-8 second period microseisms.

1.4.1 YKA -

The digital data tapes received from Yellowknife contain, for each detected signal, the identification of the beam on which the detector triggered together with the waveform data recorded at each of the 18 seismometers. In Ottawa, the trigger beam and the 4 adjacent beams in slowness space were formed and displayed for inspection. On most days slightly more than half of all detections were rejected as being false alarms; on days when signals from ice cracks were particularly prevalent a higher proportion was discarded.

The small (25 km.) aperture of the array results in a fairly sparse beamset at intervals of 0.020 sec./km. in slowness space over the range of slownesses typical of teleseisms (<0.1 sec./km.). There are a variety of schemes which can be used to estimate the 'best' beam by some form of interpolation. The method employed involved measuring the amplitude of the same cycle (usually the largest) of the P wave from each of the 5 beams formed and then applying parabolic interpolation to estimate the point in slowness space at which the amplitude would be greatest. In general this procedure worked well and a few tests showed that it almost invariably gave a slowness vector which was closer to that calculated for events of known location than that given by the trigger beam only. The slowness vector was converted to azimuth and scalar slowness and these two parameters were reported for each detection. All the analysis was carried out using the interactive waveform analysis package described in GSE/CAN/?. The parameters were all measured from the trigger beam trace.

Long-period parameters were measured from the analogue vertical component records which were mailed with the digital data tapes on a daily basis. As at MBC, N2LZ could not be measured from the records, and only N1LZ was reported.

1.5 STATISTICS OF REPORTED EVENTS

Table 3 lists the total number of events reported at each Canadian station during the Technical Test. As well as the total, the numbers of events from which signals were seen on (SP and LP) components, SP only, and LP only, are given. As might be expected from the high level of SP noise combined with the low level of LP noise at station GAC, most of the signals reported at this site are unassociated Rayleigh waves. At both MBC and YKA, roughly 10 events, the great majority being seen as short-period P waves only, were observed on an 'average' day.

The last two columns of Table 3 give the number of signals reported as being local (LA or LB) and regional (R) in character. Virtually all of the local signals are believed to be from blasting connected with mining or quarrying activity, though as always this is difficult to confirm.

Table 3

Statistics of Reported Events

Number of Events Reported, Oct 15 - Dec 14, 1984

Station	Total	(SP+LP)	SP only	LP only	Local	Regional
GAC	397	72	99	229	33	1
MBC	569	87	451	21	1	6
YKA	599	53	508	38	12	5

1.6 PROCEDURES FOR TRANSMISSION OF WMO/GTS MESSAGES

Computer programs were written to convert the output of the interactive waveform analysis program described in GSE/CAN/? into WMO/GTS format. Following a request from WASHIDC relayed by the Coordinator, these programs were modified to add the date as an additional event delimiter in early November. The other portion of this request; that parameter identifiers (e.g. P, M1X, LR etc.) be separated from its numerical value by a space, was not implemented as it appeared to contradict the international seismic code to which the GSE codes are an addition. A format checking program was used to confirm the output of these codes as well as to check the MBC messages which were composed in WMO/GTS format by the station operator.

The Canadian national GTS centre is part of the Atmospheric Environment Service (AES), located in Toronto. A 110 baud dedicated line links this with a computer at the Marine Environmental Data Service (MEDS), situated in Ottawa. When a message was ready for transmission, a dial-in connection at 300 or 1200 baud to the MEDS computer was established. The relevant file was copied to this machine and a short program run to attach the current time and insert the necessary control characters in the file. A further command sent the message to the AES in Toronto and thence onto the WMO/GTS.

The entire process was relatively straightforward and foolproof. Unfortunately no confirmation was provided that everything had indeed worked as planned. Retransmission requests received from the experimental IDCs, and an analysis of summary messages issued by other participants, indicated that some Canadian messages did not make it into the WMO/GTS. Some attempt was made to identify the point at which the messages in question disappeared, but this met with little success; the fate of lost messages can be traced up to 12 hours after transmission, but the non-appearance of the message in question was invariably not known until much later than this.

1.7 SUMMARY OF MESSAGES SENT BY CANADA

A total of 237 messages were sent by Canada during the Technical Test. Of these, 167 were original level 1 data messages, 4 were summary messages, and 2 were clarification messages addressed to Experimental IDCs. The remaining 64 were retransmissions of earlier messages; of these 39 were at the request of MOSCIDC, 3 at the request of STOCIDC, and 21 at the request of WASHIDC, and one was sent when it was realised that the wrong header had been used in message N40177. Message N40159 was unintentionally sent twice.

The Appendix describes, in excruciating detail, the date/time of transmission, 'size', and a brief description of the contents, of each message. The size of each message is expressed in a number of ways:

- Total number of lines, including blank lines
- Total number of lines, excluding blank lines
- Total number of characters, excluding blanks
- Total number of events (set of parameters reported as being from one event, preceded by a blank line and the station name and date as a delimiter)
- Total number of arrival times reported (includes M1X, M2X, M1L, M2L, MLRZ etc.)
- Total number of values reported (time, amplitude, period, azimuth, slowness, etc.)

The line/character counts are from SEISMO to STOP inclusive. A special purpose computer program (also applied to all incoming messages) was written to calculate all these entries, which are provided to give as complete a summary as possible of the contents of each message. The measure of message size (the number of lines) suggested in appendix 9 of the GSETT Procedures (CD/534) is considered in retrospect to be both inadequate and ambiguous - Canada received most messages without the blank line event delimiters, which presumably had been lost somewhere in the transmission circuits. Some messages which were received twice had differing line counts, but the contents of both were otherwise identical; the differences were not the result of missing blank lines, but rather a reorganisation of the distribution of the reported parameters between lines.

1.8 REPORTING DELAYS FOR CANADIAN STATIONS

Table 5 summarises the reporting delays (difference between start of the time period covered in a given message and the time of transmission of the message) for each Canadian station. GAC data was analysed in 24-hour segments ending at ~13:00 UT; MBC in 24-hour segments ending at ~18:00 UT; and YKA data in 24-hour segments ending at ~16:00 UT. GAC data was available more or less immediately and could be analysed and reported within 3-6 hours after the end of the reporting period, resulting in a minimum reporting delay of one day. MBC data was generally analysed by the operator within 6 hours, but the results did not reach Ottawa during normal working hours and thus could not be checked and sent until the next morning, with a corresponding minimum reporting delay of two days.

TABLE 5 - REPORTING DELAYS

Reporting delay (days)	GAC	MBC	YKA
1	37	0	0
2	16	34	2
3	5	12	12
4	1	5	18
5		3	19
6			3
7			1

The greatest delays were experienced for the array station at Yellowknife. On a very few occasions a data tape sent from YKA arrived early enough on the following day for analysis the same day, with a delay of 2 days, but usually 3-4 days was the best that could be achieved with 'overnight' mail service. The weekends posed a greater problem; data tapes mailed on Thursday and Friday (containing some data from Wednesday and Thursday respectively) usually did not arrive until Monday or even Tuesday. Data entry/analysis was carried out on a strict 'oldest-first' basis, so that immediate analysis of YKA data tapes superseded that of more recent data from GAC and MBC, delaying reporting of the latter two.

Weekend duty was required to deal with GAC data (see 1.1) and entry/analysis of data supplied by MBC and YKA was usually carried out when it was available, but a few 1-2 day delays were occasionally introduced. Data preparation, analysis and transmission, together with maintaining logs of incoming messages, required 2 persons working 50-60 hours per week for the duration of the Test. In addition to this, the additional time spent by the Mould Bay operator in measuring GSETT parameters, and the extra duty required at Yellowknife to change and send tapes daily, together constitute probably one full-time person for the duration of the Test.

2.0 RECEIPT OF WMO/GTS MESSAGES BY CANADA

2.1 PROCEDURES FOR RECEIPT OF WMO/GTS MESSAGES

The computer links described above in section 1.6 were used for the reception of messages from other participants. WMO/GTS messages with specifically designated seismic headers were automatically routed from the Canadian National GTS Centre in Toronto to the MEDS (see 1.6) computer in Ottawa, where they were saved in one large file together with the meteorological messages routinely required by the MEDS. Each morning the seismic messages were extracted from this file and stored in a secondary file. Messages received from ~12:00 UT on Fridays to ~12:00 UT on Mondays were not available until Monday morning.

Dial-up connection was established from the Seismological Centre to the MEDS computer and the file of seismic messages was copied. This dial-up connection could initially only be established at a rate of 300 baud, which meant that on occasion it took up to 4 hours to copy over the larger files. In late November an alternative connection was established using DATAPAC, a packet-switched network, which could be operated at 1200 baud, and this greatly reduced the time required for file transfer. The MEDS computer was out of operation for a few hours on November 13, December 3, and December 12, and some messages which would otherwise have been received during these periods may have been lost.

After being copied over to the Seismological Centre computer, the file containing messages received over the previous 24 hours (72 hours on Mondays) was analysed by special purpose computer programs written to determine the number of lines in each distinct message and note its time of receipt at MEDS. The file was then printed out and scanned visually for the completeness of each message, and its contents noted. The number of times each uniquely numbered message was received was determined and the text quickly searched for garbled characters. All the information thus gleaned was entered in the message log for the country of origin.

2.2 SUMMARY OF MESSAGES RECEIVED

Table 5 summarises the messages received from each participating country. (Note that several participants do not appear in this table; the reasons for this are discussed in the next section.) For each country, the number of the last message received in each distinct numbered series (e.g. 40000, 42000, 47000) is given, together with the sequence numbers of messages which were not received. On many occasions, messages which were not received were later seen as retransmissions in response to requests from experimental IDCs or other parties. 'Missing' messages whose numbers are given in brackets () in table 5 were later received as retransmissions. It is worth noting that the

TABLE 5 - Summary of Messages received by Canada

COUNTRY	CODE	SERIES	LAST	MISSING [() indicates that message in question was later received as a retransmission]
Australia	SEAU1	40000	302	(1), (16), (61), (138), (169), (200), (217), 226, (243), (278), (282), 301
	SEAU1	49000	81	(1), (14), (17), (18), (19), 20, 28, (40), (50), 60, (61), (62), (63), (65), (69), (70), 76
(COORD)	SEAU10	42000	28	1-12, (15), 16-24
Austria	SEOS1	40000	40	(15)
	SEOS1	47000	18	(9)
	SEOS1	57000	3	
Belgium	SEBX1	40000	49	(1), (4), 6, (24), (25), 37
	SEBX1	47000	11	(6), 7
Bulgaria	SEBU1	40000	49	8, 9, 10, 16, (33), (35), 37, 47
Czechoslovakia	SECZ1	40000	79	(1), (4), (20), (23), (24), 28, 31, (47), (48), (63)
	SECZ1	47000	1	
Denmark	SEDN1	40000	19	1-18
	SEDN1	50000	2	
Finland	SEFI1	40000	48	31, 38
	SEFI1	47000	3	
German D.R.	SEDD1	40000	47	(6), (7), 21, 27, (31), (32), 35, 39, 43, 44, 45
	SEDD1	47000	16	5, 6, 9, 12
F.R. Germany	SEDL1	40000	70	(22), (24)
	SEDL1	42000	1	
	SEDL1	47000	23	10, (13)
Hungary	SEHU1	40000	70	8, 16, 26-30, (38), (43), 44, 45, (53), (66)
	SEHU1	47000	6	

(continued)

TABLE 5 (continued)

COUNTRY	CODE	SERIES	LAST	MISSING
India	SEIN1	40000	60	1-28, 35, 43
Indonesia	SEID1	40000	49	2, 6, 7, 10, 13, 16, 20, 27, 28, 35-38, 41, 42
Italy	SEIY1	40000	44	(10), (29), (31)
	SEIY1	47000	8	
Japan	SEJP1	40000	69	(6), (12), (38), (41)
Netherlands	SENL1	40000	66	63
	SENL1	47000	16	
Norway	SENO11	40000	65	(38)
New Zealand	SENZ1	40000	73	(1), 5, 7-29, 32, 35-72
Sweden	SESN1	40000	176	(7), (14), 56, 128-133, 160-163
(STOCIDC)	SESN1	42000	182	(102), 119-121, 128, 140
(STOCIDC)	SESN1	52000	9	
U. S. S. R.	SERS1	40000	59	(11), 22, (35), (36), 37, (38), (41), (44), (45), 55
(MOSCIDC)	SERS1	42000	128	(1), (25), (26), (28), (42), (55), (56), (57), (65), (67), (68), (82), (87), (107)
(MOSCIDC)	SERS1	52000	31	(2), (3), (4)
U. K.	SEUK1	40000	78	(8), (27), (28), (29), (43), 69, (73), 77
	SEUK1	47000	8	
U. S. A.	SEUS2	40000	831	1-795
(WASHIDC)	SEUS10	42000	197	(1), (2), (5-12), 13-107, (108), (109), 110, 111, (112), 113-115, (116), 117-123
(WASHIDC)	SEUS10	52000	17	

retransmission procedures worked very well in the case of countries which responded promptly to requests; as an example, 17 messages from the Moscow IDC (SERS1, 42000 and 52000 series) were not received initially, but ALL of these were later received as retransmissions.

Detailed logs have been compiled for each country from which messages were received by Canada, in a form basically identical to that of the outgoing message log given in the Appendix, giving the numbers of lines, characters, events and arrival times and values contained in each message. Entries in the comment field include an indication of the number of times each message was received and an description of the contents - in particular, if the message was a retransmission of an earlier message, the number of the latter is given. These logs have been supplied to the Coordinator and can be provided upon request to any interested participant.

A total of 1845 distinct (non-duplicate) messages were received by Canada, together with 1333 duplicates. The sum of the numbers given in the column headed 'Last received' in table 5 is 3069, so this is the apparent total number of distinct messages transmitted by all the countries listed. Consequently, 1224 messages sent by these nations were not received in Canada. The great majority of these, however, are from Denmark, New Zealand and the U.S.A, for each of which (see section 10.0) most messages were not received. If these 3 countries are excluded, only 226 messages sent by the remaining countries were not received. Of these, 91 were received later as retransmissions.

A close examination of the message logs for each country (not given here) yields the following points of interest:

- Messages from most European countries (except Belgium, the Netherlands and the U.K.) were almost always received twice.

- Messages from Belgium, India and the U.S.A. were received twice about 50% of the time.

- Messages from Australia, Japan, the Netherlands, New Zealand and the U.K. were received only once.

- Messages from Italy were often received many (up to 25) times.

- The few messages received from New Zealand were all garbled and/or incomplete.

- Some messages (Belgium, New Zealand) were received incomplete apparently because of the use of = in the text.

- Many messages from the Federal Republic of Germany were received incomplete, and this is believed to be a result of the excessive length (up to 4000 ASCII characters) of these messages.

- Two U.S. (WASHIDC) messages were received with the header SEIY1 (Italy).

2.3 NON-RECEIPT OR PARTIAL RECEIPT OF MESSAGES FROM SOME COUNTRIES

The Canadian National GTS Centre in Toronto is connected to the main trunk of the GTS via the World Meteorological Centre (WMC) in Washington, U.S.A. Messages with specific headers can, upon request, be routed from Washington to Toronto. At Toronto, messages with specific headers can be rerouted to a number of points in Canada. Unfortunately, it is not possible to request that all messages with headers starting with SE (for seismic) be routed in this manner; the full header (eg. SEJP1 RJTD for Japan) must be requested.

In late August the Canadian National Seismological Centre requested the routing to Ottawa of all messages with the headers given in Appendix 2 of the GSETT Procedures (CD/534). This routing was established almost immediately for all the headers in that document except for the U.S. headers SEUS2 and SEUS10, which were not known to the person responsible for liason with Canada at the Washington WMC, and thus not implemented.

On August 28, a strike of 6 weeks duration took place at the company which, under contract, establishes message routings for the Canadian National GTS Centre. At the settlement of this labour dispute (October 15) such a large backlog of routing requests had accumulated that considerable delays resulted in the installation of new routing tables. Attempts were made to revise these tables in mid-November and again in early December, but headings requested by mid-October were not finally inserted until December 13, one day prior to the end of the level 1 data reporting period.

Information on some of the participants and headers did not reach Canada until about the start of the GSETT. These included:

- The use of header SEAU10 by the Coordinator. (This had the unfortunate consequence that Coordinator messages announcing, and giving headers for, new participants, did not reach Canada via the WMO/GTS).

- The participation of Brazil, France and Ireland

- The revised header for Zambia.

- The use of the WMO/GTS by Romania.

As soon as this information was available (the participation of Brazil, France and Ireland was only realised in studying the summary messages issued by other participants), installation of the relevant headers in the routing tables was requested, but, for the reasons given above, this was not in most cases implemented until after the end of the Test.

No messages were thus received from Brazil, France (both SEFR and SEPF headers), Ireland, Romania and Zambia. No messages were received with the U.S. header SEUS10 until December 6, with the U.S. header SEUS2 until December 13, and with the Coordinator header SEAU10 until December 15. For a few other countries, the logs show a considerable number of missing messages :

- The first 28 messages from India - this was also the U.S. experience and thus appears to be the result of problems in routing to, or at, the Wshington WMC.

- Nearly all messages from New Zealand - this was also the U.S. experience.

- About one third of all messages from Indonesia - also the U.S. experience.

- All but one message from Denmark - these were received by the U.S, so this appears to be due to routing problems from Washington to Toronto.

2.4 ALTERNATIVE MEANS OF RECEIPT OF WMO/GTS MESSAGES.

The document US/GSE/33, as well as describing the operation by the United States of experimental national and international data centres, gives instructions on how to log in to a special account on the computer used for WASHIDC operations. The 'TYMNET' (U.S. version of a packet-switching network which has analogues in most countries) access method was attempted using DATAPAC (Canadian equivalent of TYMNET) with great success.

It was extremely straightforward to connect to the WASHIDC computer and list and/or copy any files of interest under the account 'GSETT' established for the Technical Test. Transfer at 1200 baud was effected without any problem, and all messages received by the U.S. from countries whose messages were not received by Canada over the WMO/GTS were copied in several hours' connect time. With little extra effort, it would have been possible to search for and copy all messages received over the WMO/GTS by the U.S. which were, for one reason or another, not received directly by Canada.

The international packet-switched network thus appears to be an attractive alternative to the WMO/GTS for the exchange of level 1 (and probably also level 2) data, and deserves further consideration. It is readily accessible at any site with a telephone, modem and computer, and furthermore is not subject to most of the restrictions (message size limitations, rigid adherence to specific codes, etc.) required by the WMO/GTS.

Date and time given are those of transmission.

Line/character counts are from SEISMO to STOP inclusive;
l = total number of lines
nb = number of non-blank lines
c = number of non-blank characters
ev = number of events
t = number of arrival times reported (includes MiX, MiL etc.)
v = number of values (time, amplitude, period, azimuth, slowness, etc.)

Message types: C = correction; I = level 1 data; M = text message;
R = retransmission; RR = retransmission request

Message	Type	Date	Time	#l	#nb	#c	#ev	#t	#v	Comment
N40001	I	OCT16	13:53	66	61	854	4	44	132	GAC OCT15 0000 TO OCT15 1203
N40002	I	OCT17	14:03	28	25	317	3	11	39	GAC OCT15 1227 TO OCT16 1220
N40003	I	OCT18	14:28	67	61	801	6	40	126	GAC OCT16 1221 TO OCT17 1203
N40004	I		14:34	83	71	788	12	31	113	MBC OCT15 0000 TO OCT15 1802
N40005	I	OCT19	16:11	111	100	1199	11	63	201	GAC OCT17 1205 TO OCT18 1201
N40006	I		16:15	76	64	710	12	25	99	MBC OCT15 1807 TO OCT16 1746
N40007	I		16:17	38	33	359	5	15	45	YKA OCT15 0000 TO OCT16 1435
N40008	I	OCT21	13:30	66	58	670	8	31	98	YKA OCT16 1442 TO OCT17 1502
N40009	I		13:34	134	114	1165	20	50	185	MBC OCT16 1750 TO OCT18 1746
N40010	I		13:36	88	80	998	8	50	154	GAC OCT18 1204 TO OCT19 1206
N40011	I		15:56	115	105	1295	10	70	218	GAC OCT19 1208 TO OCT20 1237
N40012	I	OCT22	12:48	105	96	1204	9	65	203	GAC OCT20 1239 TO OCT21 1240
N40013	I		12:51	98	83	904	15	35	129	MBC OCT18 1751 TO OCT19 1802
N40014	I		12:54	75	64	720	11	28	103	MBC OCT19 1808 TO OCT20 1751
N40015	I	OCT23	14:06	64	59	686	5	40	118	GAC OCT21 1241 TO OCT22 1152
N40016	I		14:08	130	110	1097	20	46	172	MBC OCT20 1833 TO OCT21 1826
N40017	I		18:02	134	121	1434	13	77	249	GAC OCT22 1154 TO OCT25 1149
N40018	I		18:08	49	43	491	6	21	67	MBC OCT21 1831 TO OCT22 1809
N40019	R		18:10	113	102	1266	11	63	201	R of N40005, answer to STOCIDC N42003
N40020	I	OCT24	20:48	147	126	1442	20	61	204	YKA OCT17 1508 TO OCT19 1505

Message	Type	Date	Time	#l	#nb	#c	#ev	#t	#v	Comment
N40021	I		20:52	47	41	483	6	20	66	MBC OCT22 1813 TO OCT23 1806
N40022	I		20:54	127	110	1218	17	53	177	YKA OCT19 1510 TO OCT20 1553
N40023	I	OCT25	17:30	93	81	935	12	40	137	YKA OCT20 1600 TO OCT22 1457
N40024	I		17:35	74	63	716	11	27	103	MBC OCT23 1811 TO OCT24 1804
N40025	I	OCT26	21:15	170	153	1761	18	97	311	GAC OCT23 1131 TO OCT25 1130
N40026	I		21:19	138	120	1312	18	62	202	YKA OCT22 1502 TO OCT24 1505
N40027	I	OCT29	16:34	137	127	1590	11	90	276	GAC OCT25 1132 TO OCT26 1110
N40028	I		16:38	121	103	1127	18	45	165	MBC OCT24 1809 TO OCT25 1808
N40029	I		16:40	36	32	399	4	17	54	YKA OCT24 1509 TO OCT25 1538
N40030	I		16:42	155	140	1724	15	91	293	GAC OCT26 1142 TO OCT27 1153
N40031	I		16:45	133	119	1375	14	72	240	GAC OCT27 1154 TO OCT29 1242
N40032	I		16:50	195	166	1755	29	76	268	MBC OCT25 1813 TO OCT28 1805
N40033	I	OCT30	21:43	35	30	357	5	11	43	MBC OCT28 1810 TO OCT29 1804
N40034	I		21:45	100	87	969	13	45	146	YKA OCT25 1543 TO OCT26 1506
N40035	I		21:52	107	96	1223	11	57	183	GAC OCT29 1244 TO OCT30 1243
N40036	I	OCT31	16:52	159	141	1734	18	83	261	YKA OCT26 1511 TO OCT29 1507
N40037	I		16:57	54	48	579	6	25	75	MBC OCT29 1819 TO OCT30 1806
N40038	I		17:22	71	65	786	7	38	122	GAC OCT30 1245 TO OCT31 1238
N40039	I	NOV01	13:28	27	25	280	3	11	32	YKA OCT29 1556 TO OCT30 1554
N40040	R		13:32	78	66	777	12	25	99	R of N40006, answer to MOSCIDC N42019
N40041	R		13:38	40	35	426	5	15	45	R of N40007, answer to MOSCIDC N42019
N40042	R		13:46	68	60	737	8	31	98	R of N40008, answer to MOSCIDC N42019
N40043	R		13:53	136	116	1232	20	50	185	R of N40009, answer to MOSCIDC N42019
N40044	R		14:14	90	82	1061	8	50	154	R of N40010, answer to MOSCIDC N42019
N40045	R		14:24	117	107	1359	10	70	218	R of N40011, answer to MOSCIDC N42019
N40046	R		14:53	107	98	1271	9	65	203	R of N40012, answer to MOSCIDC N42019
N40047	R		15:01	100	85	971	15	35	129	R of N40013, answer to MOSCIDC N42019
N40048	R		15:16	77	66	788	11	28	104	R of N40014, answer to MOSCIDC N42019
N40049	R		15:24	66	61	753	5	40	118	R of N40015, answer to MOSCIDC N42019
N40050	R		15:32	132	112	1164	20	46	172	R of N40016, answer to MOSCIDC N42019
N40051	R		15:41	136	123	1499	13	77	249	R of N40017, answer to MOSCIDC N42019
N40052	R		15:49	51	45	558	6	21	67	R of N40018, answer to MOSCIDC N42019
N40053	R		15:57	115	104	1343	11	63	201	R of N40019, answer to MOSCIDC N42019
N40054	R		16:10	149	128	1509	20	61	204	R of N40020, answer to MOSCIDC N42019
N40055	R		16:19	49	43	550	6	20	66	R of N40021, answer to MOSCIDC N42019

Message	Type	Date	Time	#l	#nb	#c	#ev	#t	#v	Comment
N40056	R		16:27	129	112	1285	17	53	177	R of N40022, answer to MOSCIDC N42019
N40057	R		16:37	95	83	1002	12	40	137	R of N40023, answer to MOSCIDC N42019
N40058	R		16:45	76	65	783	11	27	103	R of N40024, answer to MOSCIDC N42019
N40059	R		16:52	172	155	1828	18	97	311	R of N40025, answer to MOSCIDC N42019
N40060	R		17:03	140	122	1380	18	62	202	R of N40026, answer to MOSCIDC N42019
N40061	R		19:24	139	129	1657	11	90	276	R of N40027, answer to MOSCIDC N42020
N40062	R		19:32	123	105	1194	18	45	165	R of N40028, answer to MOSCIDC N42020
N40063	R		19:42	38	34	466	4	17	54	R of N40029, answer to MOSCIDC N42020
N40064	R		19:49	157	142	1791	15	91	293	R of N40030, answer to MOSCIDC N42020
N40065	R		19:59	135	121	1442	14	72	240	R of N40031, answer to MOSCIDC N42020
N40066	R		20:09	197	168	1822	29	76	268	R of N40032, answer to MOSCIDC N42020
N40067	I		20:19	49	46	628	4	28	84	GAC OCT31 1239 TO NOV01 1245
N40068	I		20:28	58	50	560	8	22	77	MBC OCT30 1811 TO OCT31 1807
N40069	I	NOV02	20:13	67	57	647	10	24	86	MBC OCT31 1812 TO NOV01 1803
N40070	I		20:17	49	42	479	7	18	64	YKA OCT30 1612 TO OCT31 1609
N40071	I		20:22	90	83	1074	4	56	172	GAC NOV01 1247 TO NOV02 1246
N40072	I	NOV04	19:21	135	119	1429	16	67	229	GAC NOV02 1249 TO NOV04 1257
N40073	I		19:27	61	54	693	7	27	86	YKA OCT31 1614 TO NOV01 1604
N40074	I		19:32	147	124	1343	23	51	191	MBC NOV01 1807 TO NOV03 1809
N40075	I	NOV05	22:16	36	31	393	5	12	44	MBC NOV03 1829 TO NOV04 1843
N40076	I		22:18	84	79	1071	6	50	150	GAC NOV04 1259 TO NOV05 1243
N40077	I	NOV06	20:34	73	66	796	7	41	131	GAC NOV05 1245 TO NOV06 1229
N40078	I		20:39	66	59	701	8	32	93	YKA NOV01 1556 TO NOV02 1554
N40079	I		20:44	47	42	540	5	23	74	YKA NOV02 1608 TO NOV03 1556
N40080	I		20:49	53	46	511	8	18	70	MBC NOV04 1842 TO NOV05 1814
N40081	M		20:54	8	8	272	0	0	0	Message to MOSCIDC re retransmissions
N40082	R		20:58	101	86	1023	15	35	129	R of N40047(13), answer to MOSCIDC N42027
N40083	R		21:04	119	107	1486	11	63	201	R of N40053(19), ans. to MOSCIDC N42027
N40084	R		21:10	150	129	1561	20	61	204	R of N40054(20), answer to MOSCIDC N42027
N40085	R		21:17	50	44	602	6	20	66	R of N40055(21), answer to MOSCIDC N42027
N40086	R		21:24	130	113	1337	17	53	177	R of N40056(22), answer to MOSCIDC N42027
N40087	R		21:31	96	84	1054	12	40	137	R of N40057(23), answer to MOSCIDC N42027
N40088	R		21:37	77	66	835	11	27	103	R of N40058(24), answer to MOSCIDC N42027
N40089	R		21:42	174	156	1880	18	97	311	R of N40059(25), answer to MOSCIDC N42027
N40090	R		21:51	141	123	1432	18	62	202	R of N40060(26), answer to MOSCIDC N42027

Message	Type	Date	Time	#l	#nb	#c	#ev	#t	#v	Comment
N40091	I	NOV07	17:21	51	45	543	6	23	75	YKA NOV03 1558 TO NOV04 1554
N40092	I		17:25	70	62	776	8	35	114	YKA NOV04 1554 TO NOV05 1644
N40093	I		17:30	53	47	542	6	26	88	GAC NOV06 1230 TO NOV07 1248
N40094	I		17:32	25	22	279	3	10	34	MBC NOV05 1818 TO NOV06 1804
N40095	I	NOV08	20:58	17	16	202	2	7	22	YKA NOV05 1556 TO NOV06 1554
N40096	I		22:25	112	102	1282	11	66	212	GAC NOV07 1240 TO NOV08 1246
N40097	I	NOV11	20:11	37	34	456	4	19	61	YKA NOV06 1607 TO NOV07 1600
N40098	I		20:16	111	95	1044	16	41	147	MBC NOV06 1811 TO NOV08 1815
N40099	I		20:22	56	52	714	5	34	106	GAC NOV08 1248 TO NOV09 1235
N40100	I		20:27	89	79	1007	10	46	146	YKA NOV07 1606 TO NOV08 1626
N40101	I		20:32	34	29	348	4	13	41	MBC NOV08 1820 TO NOV09 1812
N40102	I		20:36	77	68	844	9	38	130	GAC NOV09 1241 TO NOV10 1306
N40103	I		20:41	68	58	689	10	25	91	MBC NOV09 1817 TO NOV10 1803
N40104	I		20:46	55	49	616	6	28	96	GAC NOV10 1308 TO NOV11 1301
N40105	R		20:51	53	47	607	6	23	75	R of N40091, answer to WASHIDC N42056
N40106	R		20:56	72	64	840	8	35	114	R of N40092, answer to WASHIDC N42056
N40107	R		21:01	55	49	606	6	26	88	R of N40093, answer to WASHIDC N42056
N40108	R		21:06	27	24	343	3	10	34	R of N40094, answer to WASHIDC N42056
N40109	I	NOV12	16:02	48	43	535	5	25	85	GAC NOV11 1302 TO NOV12 1303
N40110	I	NOV14	15:56	40	37	526	4	20	67	YKA NOV08 1630 TO NOV09 1509
N40111	I		16:09	122	104	1051	18	47	165	MBC NOV10 1819 TO NOV12 1813
N40112	I		16:17	5	5	106	0	0	0	GAC NOV12 1305 TO NOV13 1220
N40113	I		16:21	106	94	1220	12	54	167	YKA NOV09 1508 TO NOV10 1730
N40114	I		16:31	26	23	296	3	11	39	GAC NOV13 1221 TO NOV14 1226
N40115	M		16:37	11	11	400	0	0	0	Message to STOCIDC re retransmissions
N40116	I		17:07	100	84	978	16	33	131	MBC NOV12 1818 TO NOV13 1822
N40117	I	NOV15	14:26	99	89	1167	10	55	169	YKA NOV10 1716 TO NOV11 2400
N40118	I		14:31	103	89	1044	14	45	147	YKA NOV12 0000 TO NOV12 2400
N40119	I		14:37	65	58	759	7	34	109	YKA NOV13 0000 TO NOV13 1600
N40120	I		20:29	37	34	461	3	22	68	GAC NOV14 1226 TO NOV15 1242
N40121	I		20:34	120	101	1164	19	41	159	MBC NOV13 1827 TO NOV14 1806
N40122	I	NOV16	20:00	77	66	791	11	29	105	MBC NOV14 1812 TO NOV15 1805
N40123	I		20:07	49	45	572	5	27	87	GAC NOV15 1244 TO NOV16 1244
N40124	I		20:14	90	80	1044	10	48	153	YKA OCT13 1606 TO OCT14 1601
N40125	I	NOV17	17:11	135	120	1522	15	70	221	YKA NOV14 1608 TO NOV15 1601

Message	Type	Date	Time	#l	#nb	#c	#ev	#t	#v	Comment
N40126	I		17:22	76	69	1044	7	42	134	GAC NOV16 1245 TO NOV17 1451
N40127	I	NOV18	18:35	107	92	1014	14	42	146	MBC NOV15 1810 TO NOV17 1804
N40128	I		19:08	63	57	746	7	40	118	GAC NOV17 1453 TO NOV18 1603
N40129	I	NOV19	19:45	62	57	764	5	39	113	GAC NOV18 1604 TO NOV19 1235
N40130	I		19:51	42	36	463	6	14	52	MBC NOV17 2119 TO NOV18 1807
N40131	I	NOV20	17:23	32	29	444	3	15	48	YKA NOV15 1608 TO NOV16 1609
N40132	I		17:30	24	21	295	3	9	26	YKA NOV16 1615 TO NOV17 1550
N40133	I		17:36	58	51	644	7	27	87	MBC NOV18 1812 TO NOV19 1814
N40134	I	NOV21	14:13	53	49	680	4	33	101	GAC NOV19 1237 TO NOV20 1231
N40135	I		14:23	105	89	1064	17	52	139	YKA NOV17 1629 TO NOV18 1633
N40136	I		14:30	139	124	1626	15	74	233	YKA NOV18 1633 TO NOV19 1617
N40137	R		18:59	106	91	1112	14	45	147	R of N40118, answer to STOCIDC N42069
N40138	I		19:04	10	9	129	1	2	8	GAC NOV20 1233 TO NOV21 1233
N40139	I		19:08	59	50	529	9	20	76	MBC NOV19 1818 TO NOV20 1809
N40140	I		22:58	97	85	1051	13	40	122	YKA NOV19 1623 TO NOV20 1557
N40141	I	NOV22	21:36	52	44	545	8	16	64	MBC NOV20 1826 TO NOV21 1817
N40142	I		21:49	86	80	1026	7	56	166	GAC NOV21 1234 TO NOV22 1230
N40143	I	NOV23	19:49	131	117	1531	12	75	237	GAC NOV22 1232 TO NOV23 1234
N40144	I		19:55	46	42	621	5	19	61	YKA NOV20 1601 TO NOV21 1607
N40145	I		23:21	75	65	723	11	29	101	MBC NOV21 1822 TO NOV22 1807
N40146	I	NOV24	17:07	71	65	867	6	43	133	GAC NOV23 1235 TO NOV24 1336
N40147	I	NOV25	15:29	107	97	1321	10	62	188	YKA NOV21 1612 TO NOV22 1606
N40148	I		15:36	91	77	908	14	31	117	MBC NOV22 1811 TO NOV23 1842
N40149	I		15:48	62	53	627	9	21	77	MBC NOV23 1847 TO NOV24 1815
N40150	I		16:01	45	40	502	5	22	74	GAC NOV24 1337 TO NOV25 1326
N40151	R		16:52	105	91	1113	14	45	147	R of N40118, answer to WASHIDC N42092
N40152	R		16:57	79	68	855	11	29	105	R of N40122, answer to WASHIDC N42092
N40153	R		17:03	92	82	1113	10	48	153	R of N40124, answer to WASHIDC N42092
N40154	R		17:08	78	71	1113	7	42	134	R of N40126, answer to WASHIDC N42092
N40155	R		17:13	64	59	833	5	39	113	R of N40129, answer to WASHIDC N42092
N40156	R		17:18	55	51	749	4	33	101	R of N40134, answer to WASHIDC N42092
N40157	I	NOV26	20:19	106	97	1222	10	64	202	GAC NOV25 1329 TO NOV26 1231
N40158	I		20:28	101	85	976	16	33	129	MBC NOV24 1819 TO NOV25 1804
N40159	I	NOV27	18:46	68	62	781	6	41	127	GAC NOV26 1233 TO NOV27 1236
		NOV28	01:12							Sent again in error

Message	Type	Date	Time	#l	#nb	#c	#ev	#t	#v	Comment
N40160	I	NOV27	18:52	94	80	925	14	35	125	MBC NOV25 1809 TO NOV26 1804
N40161	I	NOV28	01:20	120	105	1284	16	54	178	YKA NOV22 1613 TO NOV23 1557
N40162	I		16:13	24	21	238	3	8	28	MBC NOV26 1809 TO NOV27 1804
N40163	I		16:38	67	61	781	6	39	121	GAC NOV27 1236 TO NOV28 1238
N40164	I		21:30	47	42	554	6	21	62	YKA NOV23 1602 TO NOV24 1602
N40165	I	NOV29	14:28	152	134	1681	18	76	247	YKA NOV24 1555 TO NOV25 1555
N40166	I		14:36	102	91	1175	11	55	172	YKA NOV25 1556 TO NOV26 1554
N40167	I		16:02	30	27	339	3	15	49	GAC NOV28 1238 TO NOV29 1255
N40168	I		16:10	58	51	575	8	24	78	MBC NOV27 1809 TO NOV28 1804
N40169	I		22:46	97	85	994	13	43	138	YKA NOV26 1604 TO NOV27 1604
N40170	I	DEC01	02:00	135	114	1314	21	47	181	MBC NOV28 1810 TO NOV29 1805
N40171	I		02:07	83	77	1020	7	53	163	GAC NOV29 1257 TO NOV30 1237
N40172	I		02:15	126	113	1474	13	71	218	YKA NOV27 1608 TO NOV29 1557
N40173	I	DEC02	16:14	47	44	590	4	28	88	GAC NOV30 1239 TO DEC01 1312
N40174	I		17:01	172	149	1790	24	72	235	YKA NOV28 1557 TO NOV29 1605
N40175	I		17:25	62	58	810	5	40	122	GAC DEC01 1374 TO DEC02 1259
N40176	I		17:34	51	45	505	8	18	68	MBC NOV29 1810 TO NOV30 1804
N40177	I		17:46	41	36	398	6	14	54	MBC NOV30 1809 TO DEC01 1807, bad header
N40178	R	DEC03	20:21	43	38	485	6	14	54	R of N40177, header corrected
N40179	I		20:28	68	62	796	6	41	127	GAC DEC02 1300 TO DEC03 1246
N40180	R		20:33	26	23	307	3	8	28	R of N40162, answer to WASHIDC N42111
N40181	R		20:42	69	63	850	6	39	121	R of N40163, answer to WASHIDC N42111
N40182	R		20:48	49	44	623	6	21	62	R of N40164, answer to WASHIDC N42111
N40183	I		20:57	64	56	647	9	23	79	MBC DEC01 1831 TO DEC02 1802
N40184	I	DEC04	21:38	66	58	703	8	30	106	GAC DEC03 1247 TO DEC04 1237
N40185	I		21:46	112	98	1187	15	50	161	YKA NOV29 1611 TO NOV30 1638
N40186	I		21:55	53	46	552	7	22	72	MBC DEC02 1807 TO DEC03 1802
N40187	I	DEC05	20:59	54	49	613	5	31	99	GAC DEC04 1238 TO DEC05 1235
N40188	I		21:05	27	24	298	3	11	33	MBC DEC03 1807 TO DEC04 1805
N40189	R		21:09	45	40	568	6	14	54	R of N40178(177), answer to STOCIDC N42122
N40190	I	DEC06	16:55	115	101	1283	14	56	182	YKA NOV30 1646 TO DEC01 1708
N40191	I		17:02	106	91	1109	15	45	144	YKA DEC01 1718 TO DEC03 1556
N40192	I		18:05	99	87	1035	13	44	141	YKA DEC03 1601 TO DEC04 1556
N40193	I		18:10	58	52	640	6	30	98	GAC DEC05 1236 TO DEC06 1250
N40194	I		22:29	45	39	440	7	15	59	MBC DEC04 1809 TO DEC05 1804

Message	Type	Date	Time	#l	#nb	#c	#ev	#t	#v	Comment
N40195	I	DEC09	19:04	90	76	826	14	30	118	MBC DEC05 1809 TO DEC06 1802
N40196	I		19:09	50	47	652	4	30	90	GAC DEC06 1252 TO DEC07 0800
N40197	I		19:14	35	33	465	3	18	58	GAC DEC07 1241 TO DEC08 1243
N40198	I		19:20	33	29	370	4	14	50	GAC DEC08 1324 TO DEC09 1307
N40199	I		19:25	126	112	1446	14	66	212	YKA DEC04 1603 TO DEC05 1526
N40200	I		19:31	103	92	1206	11	55	173	YKA DEC05 1532 TO DEC06 1533
N40201	I		19:36	73	63	737	10	30	100	MBC DEC06 1806 TO DEC07 1803
N40202	I		19:43	43	37	459	6	16	56	MBC DEC07 1807 TO DEC08 1803
N40203	I	DEC10	22:25	49	42	496	7	17	61	MBC DEC08 1808 TO DEC09 1802
N40204	I		22:31	111	103	1374	9	72	216	GAC DEC09 1309 TO DEC10 1248
N40205	I	DEC11	20:29	94	84	1086	10	51	157	YKA DEC06 1537 TO DEC07 1521
N40206	I		20:38	89	77	942	12	39	123	YKA DEC07 1529 TO DEC08 1634
N40207	I		20:47	62	57	750	6	36	118	GAC DEC10 1250 TO DEC11 1241
N40208	I		20:54	33	29	366	4	14	44	MBC DEC09 1807 TO DEC10 1804
N40209	I	DEC12	16:56	140	125	1654	15	76	244	YKA DEC08 1640 TO DEC09 1641
N40210	I		17:07	133	116	1381	18	59	195	YKA DEC09 1641 TO DEC10 1534
N40211	I		20:39	16	14	193	2	5	19	MBC DEC10 1808 TO DEC11 1804
N40212	I		20:44	53	50	697	4	35	105	GAC DEC11 1243 TO DEC12 1237
N40213	I	DEC14	16:17	29	26	329	3	14	42	MBC DEC11 1818 TO DEC12 1803
N40214	I		16:23	65	57	682	9	27	90	YKA DEC10 1643 TO DEC11 1547
N40215	I		16:28	65	60	831	5	41	125	GAC DEC12 1251 TO DEC13 1236
N40216	R		16:33	30	27	386	3	11	39	R of N40002, answer to WASHIDC N42158
N40217	R		16:38	69	63	870	6	40	126	R of N40003, answer to WASHIDC N42158
N40218	R		16:43	85	73	857	12	31	113	R of N40004, answer to WASHIDC N42158
N40219	R		16:48	113	102	1268	11	63	201	R of N40005, answer to WASHIDC N42158
N40220	R		16:55	85	79	1089	7	53	163	R of N40071, answer to WASHIDC N42158
N40221	R		17:00	174	151	1859	24	72	235	R of N40174, answer to WASHIDC N42158
N40222	R		17:06	108	93	1178	15	45	144	R of N40191, answer to WASHIDC N42158
N40223	R		17:16	101	89	1103	13	44	141	R of N40192, answer to WASHIDC N42158
N40224	I		19:52	63	58	732	6	38	118	GAC DEC13 1252 TO DEC14 1302
N40225	I		19:55	56	48	544	9	18	72	MBC DEC12 1808 TO DEC13 1806
N40226	I	DEC16	21:13	24	22	322	2	12	38	GAC DEC14 1237 TO DEC14 2400, last GAC
N40227	I		21:20	50	46	686	4	29	89	YKA DEC11 1551 TO DEC12 1620
N40228	I		21:29	78	66	799	12	26	100	MBC DEC13 1811 TO DEC14 2400, last MBC
N40229	I		21:34	86	77	1020	9	47	148	YKA DEC12 1624 TO DEC13 1532

Message	Type.	Date	Time	#1	#nb	#c	#ev	#t	#v.	Comment
N40230	I	DEC18	21:17	86	77	1006	9	46	148	YKA DEC13 1537 TO DEC14 0100
N40231	I		21:24	127	110	1340	17	55	182	YKA DEC14 0100 TO DEC14 2400, last YKA
N40232	R	DEC19	16:38	136	118	1468	18	59	195	R of N40210, answer to MOSCIDC N42112
N40233	R		16:44	19	16	280	2	5	19	R of N40211, answer to MOSCIDC N42112
N40234	R		16:51	56	52	784	4	35	105	R of N40212, answer to MOSCIDC N42112
N47001	S	NOV02	20:27	43	43	1254	0	0	0	Summary, GSETT days 1-14
N47002	S	NOV18	18:23	46	46	1290	0	0	0	Summary, GSETT days 15-28
N47003	S	NOV26	20:35	45	45	1313	0	0	0	Summary, GSETT days 29-42
N47004	S	DEC20	19:42	44	44	1092	0	0	0	Summary, GSETT days 43-56

CANADIAN DELEGATION

GSE/CAN/10
15 March 1985

INTERACTIVE WAVEFORM ANALYSIS METHODS USED DURING THE GSE TECHNICAL TEST

As noted in GSE/CAN/9, Level 1 parameters for Canadian stations GAC (Glen Almond, Quebec) and YKA (Yellowknife array) were derived from digital data. This document briefly describes the interactive analysis methods developed and applied to measure the required parameters from the digital waveforms.

For several years a computer code called Seismic Data Analysis Monitor (SAM) has been under development, primarily for use in the analysis of digital data recorded by the 20-station Eastern Canada Telemetered Network (ECTN), received in real time at Ottawa. The program, implemented on both monochrome and colour display terminals, carries out event and waveform selection, interactive waveform display and phase picking, waveform editing, and event location using the phase picks. For most of these features the methods used are tailored to the use of high-frequency ECTN data for the location and analysis of small events recorded only to regional (< 1000 km) distances.

All the short-period level 1 parameters, including the noise measurements, can be measured as if they were phases being picked by an analyst, since each usually consists of one or more of (time, amplitude, period). Consequently the phase picking techniques already implemented in SAM could be used for M1X-M4X, MSSN, NSZ, etc., as well as the more traditional and familiar phase arrival times, amplitudes and periods. This was attempted on a trial basis and proved to be quite feasible, but extremely time-consuming. The long period parameters M1L-M4L could be painfully extracted by a trial and error process to find the relevant cycle of the waveform with a period closest to that required for each.

Fortunately, the definitions of the parameters M1X-M4X and M1L-M4L are generally sufficiently unambiguous for it to be possible to automate their measurement once the onset of P and the Rayleigh wave has been selected by an analyst. Three special routines were developed for use in the Technical Test:

PK1: Requests P onset time pick and quality, then automatically determines first motion, and times, amplitudes and periods for M1X-M4X as well as short-period noise in the preceding 30-seconds.

PK2: Requests phase onset time pick, name, and quality (I/E), and then automatically determines maximum amplitude and dominant period within a user-specified time interval after the picked onset time. Mainly used for picking secondary phases and obtaining the Love wave parameters LQ, MLQN and MLQE.

PK3: Requests LRZ onset time, then automatically obtains time, amplitude and period for MLRZ and M1L-M4L, as well as NLZ in the 60-seconds preceding the onset time. The user specifies the time interval after LRZ to be searched for M1L-M4L.

In each of these modules the maximum amplitudes are determined by searching for subsequent extrema (peaks and troughs) of the waveform over the time interval specified. The difference in amplitude is stored and the half-cycle with the largest peak-trough difference is chosen. A box is drawn to indicate the half-cycle selected. This technique worked well for about 90% of the picks made, errors generally occurring when there was contamination of the trace by frequencies significantly greater or less than that of the dominant signal. User over-ride of the automatically determined parameters is therefore provided as follows:

- the half-cycle chosen may be reselected by positioning a cursor halfway between the desired peak and trough. The time at which the cursor is positioned becomes the time associated with the measurements. The routine then searches for adjacent extrema and draws a box to indicate the amplitude and half-period.

- if the cycle chosen is correct, but the peak and/or trough considered incorrect, the user may position the cursor at the exact points defining the peak and trough to be used.

Use of these special purpose pick routines was greatly aided by their implementation on a colour terminal with its own memory storage, providing 'firmware' 'ZOOM' and 'PAN' capability. Thus the waveforms could be drawn at a scale which was marginally satisfactory, the zoom/pan capability providing rapid scale enlargement should difficulties arise in picking onset time or revising amplitude/period picks. All picks made are saved in a disk file which was then translated into WMO/GTS code.

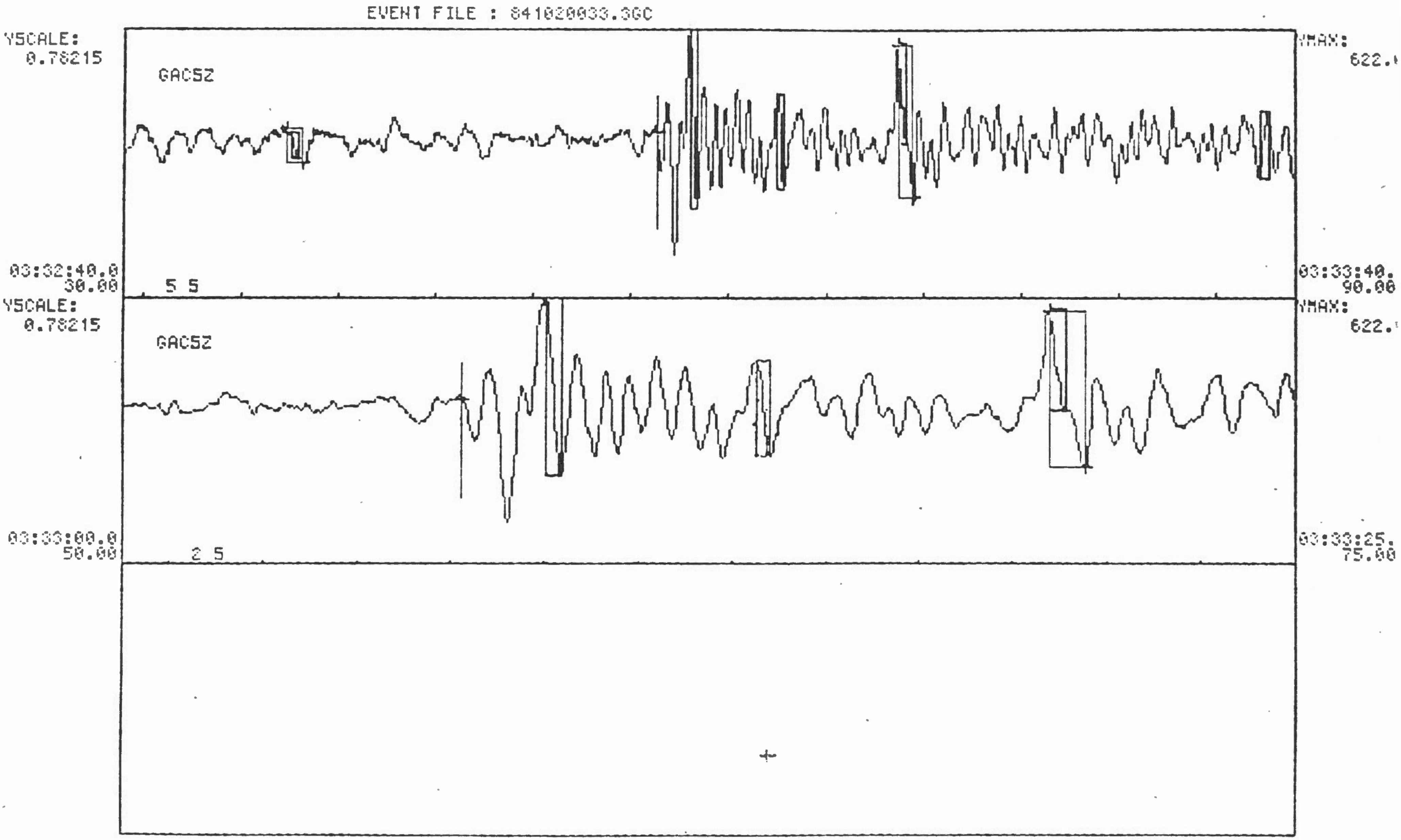
The two accompanying figures illustrate the use of each of PK1, PK2 and PK3 for the measurement of M1X-M4X (figure 1) and MLRZ, M1L-M4L, MLQN and MLQE (figure 2), on a colour graphics display terminal. Colour is effectively used to distinguish automatic and interactive measurements. Use of these procedures greatly reduced the effort and time required to measure the prescribed parameters from the 974 digitally recorded waveforms measured and reported by Canada.

FIGURES

The two following figures illustrate the use of SAM to obtain level 1 parameters. In each, the red vertical bars indicate phase onset time picks made by the analyst. The red boxes show the half-cycle selected automatically for (time, amplitude, period) of maxima; the blue boxes indicate that these have been superseded by analyst interaction and outline the half-cycle preferred by the analyst. It should be noted that picks were generally made from displays at larger scales for the sake of accuracy; this was usually accomplished by using the 'zoom and pan' capability of the display terminal, rather than by replotting.

Figure 1: Short-period vertical component data recorded by station GAC. The top trace (60 seconds in length) shows the analyst-picked P onset time. The red box preceding this indicates the cycle selected for noise measurement, and the boxes after the P onset denote M1X, M2X, M3X and M4X. The blue boxes show analyst revision, by picking both peak and trough, of the cycles chosen for NSZ and M3X. The lower trace shows the centre 15 seconds of the top trace on an expanded time scale, with the same picks.

Figure 2: Three-component long period data (from the top, Z, N-S and E-W) recorded at GAC from a large event. The top trace illustrates the use of PK3 to obtain level 1 Rayleigh wave parameters. The LRZ time picked is indicated by the red bar and the boxes following this are for M4L, M3L, MLRZ (24-second period), M2L, and M1L. The M1L measurement was rejected as the closest period to 10 seconds that could be obtained was 16 seconds. The box for N2LZ (preceding the LRZ onset) clearly contains signal and not noise, and a revised noise pick would have to be made before the P-wave onset (not shown). The following horizontal traces illustrate selection of onset time and peak amplitude (with period and time) for a prominent secondary phase (from its elliptical polarisation, probably a shear-coupled PL wave) and the Love wave. The analyst phase onset time picks are only saved for the N-S component. Note that the same cycles were automatically selected for the Love waves on the N-S and E-W components (MLQN and MLQE), but that for the earlier phase the analyst had to revise the automatically picked cycle on the E-W trace so that it corresponds with that made on the N-S trace (analyst choice shown by blue box).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YMAX:
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5 5
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90.00
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622.
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50.00
2 5
03:33:25.
75.00

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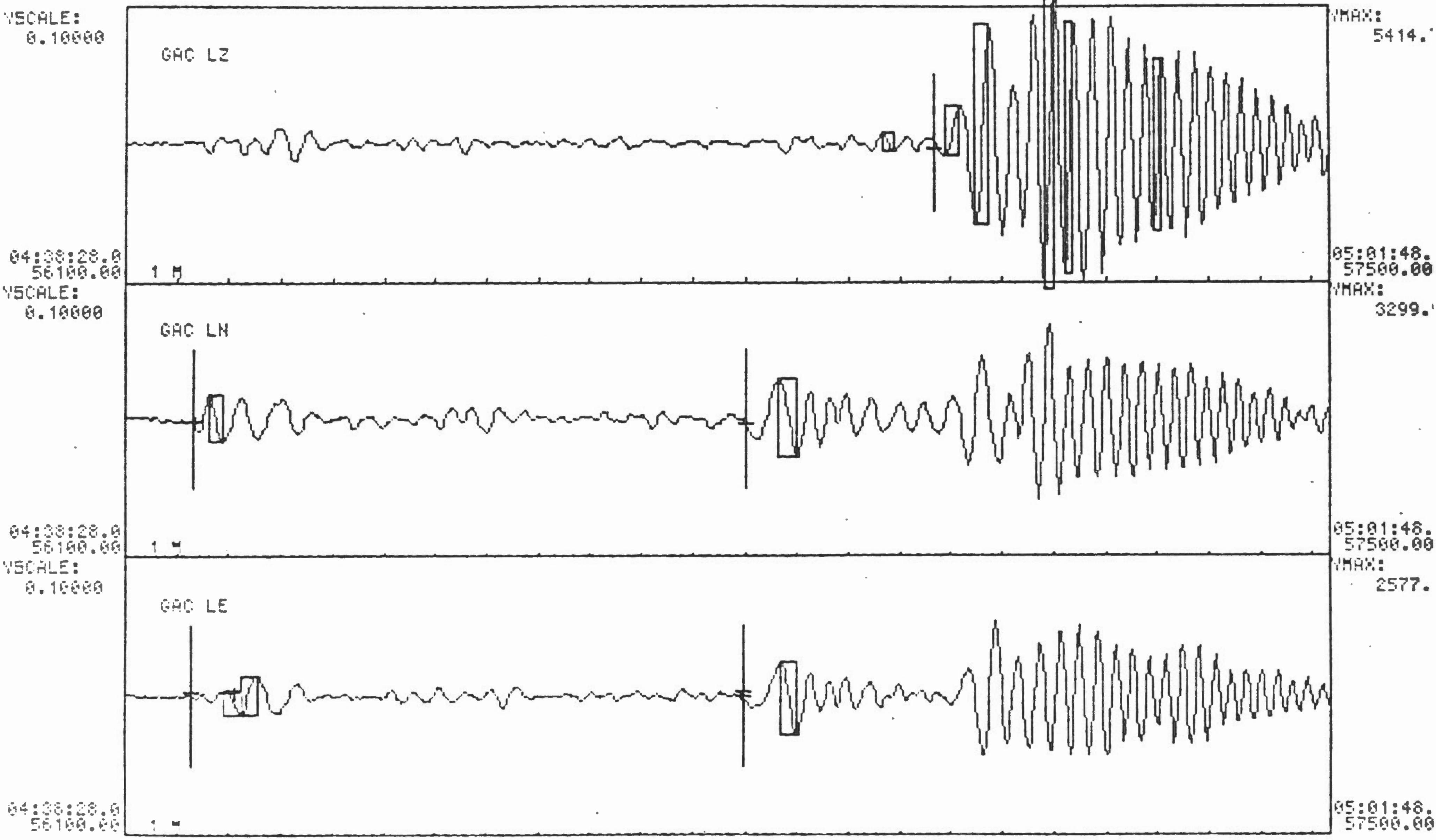

CANADIAN DELEGATION

GSE/CAN/11
15 March 1985

EVALUATION OF GSETT (1984) - LEVEL 1 PARAMETERS

The following is in response to a letter from the convenor of GSE/SG2, dated February 27, 1985, requesting information on the above topic from all participants.

1. Number of times each parameter was reported.

Summarised in the two attached tables. The full set of parameters was reported from station GAC, and the minimum set from stations MBC and YKA. For the latter, M2X-M4X was reported as well, if time was available.

2. Parameter extraction procedures.

Parameter measurement at the analogue station MBC was carried out manually. For GAC and YKA, parameters were measured using the procedures described in GSE/CAN/10, which can be briefly summarised as follows:

> An interactive waveform display program was used to plot the traces identified and saved by an automatic signal detection algoithm. An analyst interactively selected phase onset times. To automatically determine the maximum amplitude and the corresponding dominant period and time, the trace following the time pick is scanned for an analyst-specified time period to find the time and amplitude of all extrema (peaks and troughs). These values are temporarily stored and then a search is made for the pair of adjacent extrema with the largest difference. The time of the maximum is given by that of zero-crossing, or, if no zero crossing exists, by the point halfway in time between the extrema. Addition of a check upon dominant period enabled this method to be used for the long-period parameters as well. Noise values were determined by applying the same search technique to the trace before the time pick, over the specified time intervals. An interactive capability permitted analyst rejection and/or revision of automatic measurements. Only about 20% of the automatic measurements required revision.

3. Workload.

The minimum set of parameters measured manually at station MBC took between two and four hours to measure each day. On average, nine short-period and two long-period signals were analysed daily.

For station GAC (full parameter set), about three hours were required daily. If these measurements had been made manually, it is estimated that the time required would have at least doubled. Per day, an average of three short-period and five long-period signals were processed.

For YKA (usually minimum parameter set), about five hours was needed each day; some of this was used to determine the optimum beam for which slowness and azimuth were reported. An average of nine short-period and two long-period signals were analysed daily.

4. Proposed improvements to instructions.

Some difficulties were encountered in unambiguously interpreting the instructions for the extraction of M4L, M3L etc. For M2L, for example, should the largest amplitude cycle with a period in the range 18-22 seconds be reported, or should it be the cycle with period closest to 20 seconds? Occasionally, the largest amplitude at a given period was in a later (multipathed) group of surface waves - should the first arriving group be preferred for measurement of MiL?

In the case of the short-period parameters M1X, M2X etc., the largest amplitude within a given time window was frequently that of a secondary phase. Should the arrival of the latter be taken to indicate the formal end of P, and if so, should the set of measurements M1X, M2X, M3X and M4X be terminated at this time?

Considerable difficulty was sometimes encountered in measuring noise amplitude. N1LZ could not be measured at station GAC because of the poor response of the instrument at periods less than ~ 12 seconds. In general, the long-period noise at statins MBC and YKA was overwhelmingly dominated by 4-8 second microseisms, and N2LZ could not be measured. The short-period noise at stations GAC and MBC contained a wide range of frequencies, and it was often difficult to predict which corresponded to the greatest amount of ground displacement (the greatest trace amplitude was unambiguous). The noise measurements were in many respects the most time consuming and frustrating to make. The following changes are proposed:

(a) NSZ should be measured at a stated distinct period, such a one second, irrespective of the frequency of the signal.

(b) The noise measurements are time consuming and should not be required to be reported with every signal. On the other hand, if a station reports no signals, no noise levels will be available. Noise levels at set frequencies (such as 1, 0.125 and 0.05 Hz.) should be reported at specified (e.g. every six hours) and regular intervals.

At station GAC, the most prominent phase for local events is often the short (0.5-2.0 seconds) period fundamental mode Rayleigh wave, known as Rg. As it is only generated by events of shallow (usually < 3 km.) depth, it is an important diagnostic phase. Rg is not included in the list of permitted phases under the International Seismic Code. This omission should be corrected.

SHORT PERIOD PARAMETERS:
NUMBER OF TIMES REPORTED

	GAC	MBC	YKA
P	151	531	557
PCP			1
PKP	1		
PN	2		
PG	14		1
M1X	162	529	555
M2X	116		177
M3X	96		126
M4X	68		69
NSZ	392	559	577
AP	6	26	18
APCP			1
XP	1.		
RG	21		1
Unidentified secondary phase	26	49	121
LG	2		1
Max. LG, SZ	1		
SN	2		
SE	2		
S	8	29	7
SN	2		
SG	4		1
Max. S, SN	8		
SE	8		
Max. SG, SN	5		
SE	5		
Max. SN, SN	2		
SE	2		
AZ			537
SLO			537

LONG PERIOD PARAMETERS:
NUMBER OF TIMES REPORTED

	GAC	MBC	YKA
P	24		11
PDIF	1		1
PKP	1		1
MPLZ	16		3
MPDIFLZ	1		
MPKPLZ	1		
MPLN	1		
Unidentified secondary phase, LZ component	12	1	5
LN	2		
LE	1		
LR	303.	110	90
MLRZ	301	104	
M1L	10		
M2L	292		2
M3L	289		1
M4L	222		
N1LZ	2	559	547
N2LZ	399		19
S	30	16	
SKS	1		
Max. S/SKS LN	29		
LE	30		
LQ	69		
MLQZ	133		